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Norwest Assists OSEC with New Oil Shale Development

by Steven Kerr



Oil shale in the Green River Formation. The particularly dark band across the center of the photograph is known as the Mahogany Bed. Retorting can capture as much as 70 gal/ton of oil from the Mahogany Bed.

Over the past few years there has been renewed activity in the oil shale deposits of Utah and Colorado. Norwest has been assisting Oil Shale Exploration Company (OSEC) with its endeavors to develop its oil shale resources located near the White River in eastern Utah. In late 2008, OSEC entered into a business arrangement with Petrobras

and Mitsui to develop oil shale on a commercial basis. This led to the preparation of an extensive commercial feasibility study in 2009 for which Norwest was a major contributor.

Development Options Evaluated

The feasibility study first evaluated two development options. The first option was to continue with

the underground development initiated by the White River

Shale Oil Company (WRSOC) in the late 70s and early 80s, a joint venture project of Sun Oil, Phillips Petroleum, and SOHIO. The WRSOC project came to a halt in 1982 with declining petroleum prices. WRSOC subsequently turned the mine and surface facilities back over to the BLM. While this

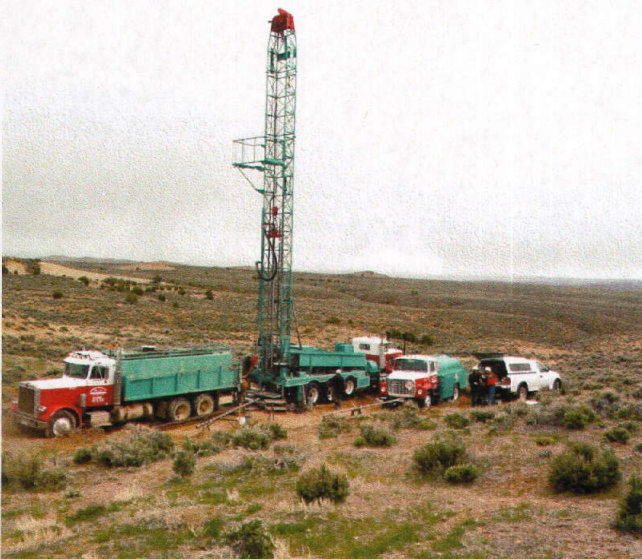
option comes with a large mine shaft, decline, surface facilities, and defined resources, it also involves dealing with certain permitting and landowner issues and is strictly limited to underground mining.

The second option looked at starting a completely new mine development farther south from the White River Mine on land owned by OSEC, known as the Skyline property. Developing the Skyline property involves a less complex permitting process and landowner issues are simplified since a majority of the property

to be developed is owned by OSEC. The feasibility study opted for the second option with a plan to develop surface and underground mining on the Skyline property and a surface facility that includes 12 Petrosix retorts. The one significant drawback to the Skyline property however, was the lack of geologic information characterizing the property. Large portions of the property have never been drilled and much of the area was classified as an inferred resource. This issue was addressed this year when Norwest carried out a core drilling program on the Skyline property for OSEC and its partners.

Drilling Program Near Completion

During May 2010, 2 rigs completed 11 drill holes, for a combined 5,500 ft of drilling. Geologists Joe Cain, Alex Garhart, Eric Martin, and Lindsay Tingey managed drilling operations, logged core, and identified sample horizons for subsequent assays to determine oil content. The program is now nearing completion. Norwest is still waiting on the results for approximately half of the 1,200 samples submitted for testing. Assay results received thus far, combined with the down-hole geophysics, indicate that Norwest will be successful in validating previous resource estimates for the property. All drill sites have now been reclaimed and final reseeded of the disturbed areas is scheduled to take place at the end of October 2010.



Drilling on the Skyline property

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Unconventional Energy

by Joe Aiello

With the continuing depletion of conventional energy resources, the search for and development of less traditional forms of energy has intensified.

Many of these energy forms fall into the category of "unconventional energy", including methane derived from coal seams (coalbed methane, coal mine methane etc.), underground coal gasification, shale gas, oil shale, methane hydrates, biofuels, and geothermal. Unconventional energy options span the development continuum from currently technologically unrecoverable (i.e. methane hydrates) to commercially viable. They are dependent on the right combination of technology, energy pricing, regulatory environment and public acceptance (particularly in developed countries) to become a meaningful part of our energy mix.

The latter two elements, regulatory environment and public acceptance, are taking on greater significance in energy resource development. As unconventional energy sources are developed, the use of new technologies or different techniques may be brought to bear, changes which have the potential to create unanticipated challenges. In the absence of a well founded, mature regulatory environment, those unanticipated challenges can evolve into serious issues on the public policy front leading to widespread public opposition. With emerging unconventional energy

sources, the regulatory regime is often in "catch up" mode, trying to understand the potential risks associated with new or different technologies being applied in new or different physical environments, and potentially creating a regulatory gap. An example of this is found in the early development of coalbed methane (CBM) in the western US where the management of produced water was not subject to tight regulatory controls. While those early problems have been resolved they remain a rallying point for those that oppose CBM development in other parts of North America. We see a similar narrative unfolding related to shale gas, which is seen as having the potential to provide large supplies of a cleaner, low-cost fuel for decades. However there are concerns that the hydraulic fracturing process, which involves the high pressure injection of chemically-treated water into the shale, may impact the quality of water in areas being developed. In the absence of a comprehensive regulatory regime dealing with hydraulic fracturing, strong opposition to shale gas development has taken hold in a number of areas.

This can create a dilemma for resource developers and regulators alike. Often the practical approach to confirm the challenges and risks associated with development is through a pilot scale test; however at times even conducting



Joe Aiello,
Managing Director and President

the necessary pilot work is precluded by public opposition. To advance the case for responsible development of our unconventional energy resources, there is a need to understand the challenges and risks associated with development, and to identify solutions and risk mitigation options to resolve them. This will support the process of crafting a regulatory framework that is timely, robust and transparent. The articles on Bloodwood Creek (underground coal gasification) and A Tale of Three Basins (coal bed methane) provide examples of how Norwest is able to work with clients to contribute a higher level of technical understanding of a project or process in support of resource development in an environmentally and socially responsible manner.

Suncor Pond 1 Reclamation

By Erin Olason



Wapisiw Lookout, September 2010

Suncor Energy Inc. was the first commercially operating oil sands producer in Canada, and as part of their initial start-up, Tailings

trafficable surface over the 12 hectare area of soft tailings within Pond 1. In the years leading up to 2010, Norwest worked with Suncor to

Pond 1 was constructed in 1967. Pond 1 was in active use between 1967 and 1999, providing containment for liquid fine tailings. Several years ago, Suncor made a commitment to achieve the closure of Pond 1 to a trafficable surface by the end of 2010. Between January and April 2010, Norwest participated in the construction of the

characterize the geotechnical properties of the soft tailings and to develop concepts for creating a trafficable surface from which final reclamation activities could begin. Norwest's design involved placing a sand cap during winter conditions, when small equipment could safely traffic the frozen tailings. Geogrid was used to provide additional support in case of weak or thin frozen layers.

Norwest personnel were on-site during the sand cap construction to provide geotechnical direction to Suncor and its contractors. Conditions varied over the winter, with temperatures ranging from approximately -40°C to +10°C (-40°F to 50°F). The initial geogrid layer was deployed by hand and the sand was spread over the frozen tailings in a one meter lift using small bulldozers. Once this initial stabilizing lift was in place, larger equipment was used to place the second 1m sand lift, which

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A Tale of Three Basins

Responding to an Unconventional Challenge

by Seth Okeson, James Thomson, and Mike LeFrancois

Water management is a common challenge associated with unconventional energy, whether it is the handling of produced water, or provision of water for hydraulic fracturing and other development activities. Norwest's Denver office has a focus on water management with decades of experience in unconventional resources including coal bed methane (CBM), oil shale, tight gas, oil sands, and underground coal gasification (UCG).

New Regulatory Requirements

Recent court rulings and new regulatory requirements for produced water in Colorado put CBM production at risk. The Colorado Division of Water Resources (DWR) began regulating water produced from CBM operations as potentially impacting surface water right owners. A simplistic first pass evaluation of impacts sponsored by the DWR suggested that the amount of surface water taken ("depleted") by the pumping of CBM wells could be similar in magnitude to the volumes of groundwater produced. Compensating ("augmenting") for these depletions would be necessary for continued operations and would require the purchase of water rights and the augmentation of surface water depletions in time, place, and amount.

The DWR recognized the need for more rigorous analysis and began a rulemaking process through which areas of oil and gas production with minimal groundwater depletions (termed "nontributary" groundwater) could be determined. At this time, the DWR's focus has expanded from CBM operations to include all oil and gas production in Colorado. The standards of proof necessary in support of the proposed nontributary rules included hydrogeologic characterization and either numerical or analytical modeling of groundwater and surface water interaction.

Norwest Experience

Numerical modeling of groundwater flow is a core function of Norwest's Denver office. Equally important is the experience in modeling the impacts of CBM operations on groundwater flow. Prior CBM groundwater modeling projects included numerical models of the San Juan Basin in Colorado and New Mexico, the Powder River Basin in Wyoming, and the Bowen Basin in Australia. Recent court rulings and new regulatory requirements for produced water in Colorado put CBM production at risk. The

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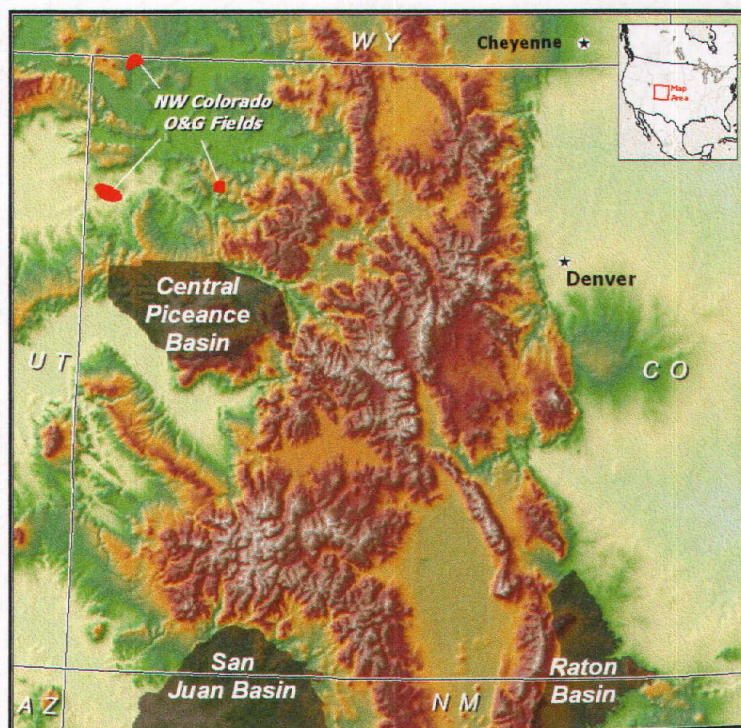
DWR Hearings

As the DWR hearing expanded to non-CBM oil and gas operations, Norwest worked for other operators preparing geologic and hydrologic interpretations of the central Piceance Basin and three nearby producing fields (see figure). The workflow for these projects

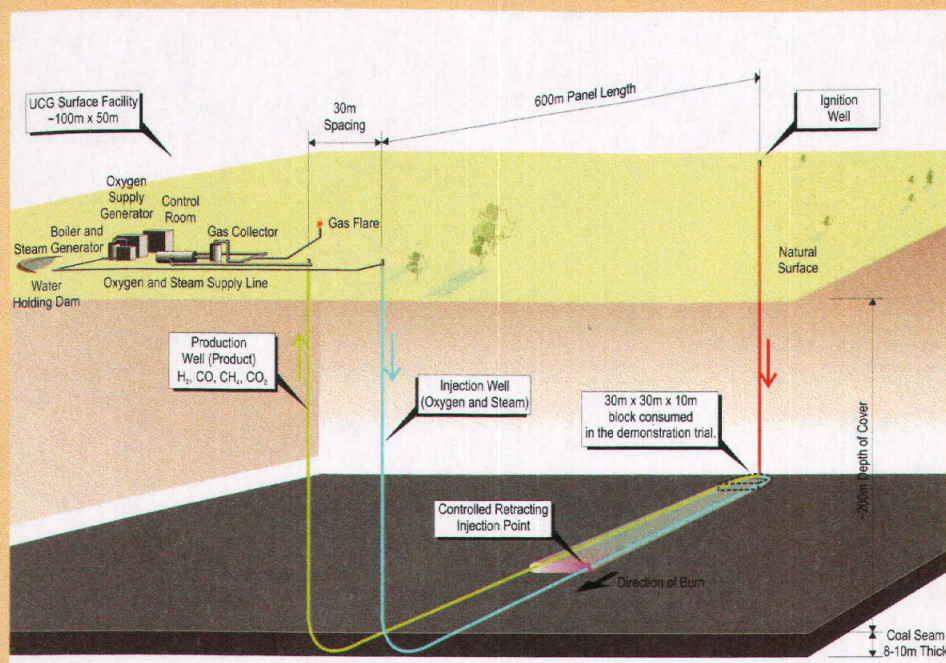
was similar, with data compilation and analysis supporting the development of conceptual models of groundwater flow. Norwest evaluated the areas of nontributary groundwater for these projects using analytic models. The analytical models provided very conservative first pass results that showed the producing zones were nontributary and provided a cost-effective modeling approach for these areas.

Norwest employees gave testimony at the DWR hearings including adversarial cross examination by parties opposing the proposed rules. The DWR adopted rules based on Norwest's modeling and testimony for each of the areas that Norwest worked on. Surface water depletions were calculated for CBM operations in tributary groundwater areas with depletions being several orders of magnitude lower than those calculated in the initial simplistic evaluation.

Overall, Norwest assisted operators in dealing with an unconventional regulatory challenge to their oil and gas operations in Colorado. Norwest used modeling tools of the appropriate complexity to evaluate impacts to surface water from the co-production of groundwater with oil and gas. Our clients gained regulatory certainty from the DWR rules, are able to and can proceed with current production, and can now factor in the regulatory cost in evaluations of future investment.



Locations of Modeled Basins



Bloodwood Creek UCG Process (courtesy of Carbon Energy Pty Ltd.)

Underground Coal Gasification at Bloodwood Creek (Queensland, Australia) by Michael Day

Norwest, in partnership with Brisbane-based Ausenco, has recently been engaged by Carbon Energy Pty Ltd (CEPL) to perform hydrogeologic modeling of their Underground Coal Gasification (UCG) demonstration site at Bloodwood Creek in Queensland, Australia. UCG is an unconventional technology that involves the controlled in-situ gasification of coal to produce energy in the form of syngas (primarily hydrogen and carbon monoxide). The CEPL process involves the drilling of parallel horizontal wells within the coal seam of each UCG "panel" (see figure). One well is used for the introduction of oxygen and steam to support the combustion of the coal, and the other well is used for the production of the produced syngas. A commercial UCG operation would involve several panels, operating simultaneously.

Accesses Large Reserves with Minimal Environmental Impact

UCG provides the opportunity to utilize large reserves of otherwise inaccessible coal, minimizing the environmental impact of extraction. The footprint of UCG is small compared with coal seam gas and conventional mining, and the additional resource recovery can be substantial. There is a growing worldwide interest in UCG as an alternative fuel source.

The focus of CEPL's Bloodwood Creek trial has been on the control of chemical reactions occurring during the UCG process to produce a consistent, high quality syngas in commercial quantities, with the highest levels of environmental performance. The protection of ground water resources is a key element of the demonstration project. Groundwater quality may be impacted during operations if combustion gases migrate from the UCG chamber. Gas containment is generally achieved by operating the UCG chamber below hydrostatic pressures such that a sufficient inward hydraulic gradient is maintained. The numerical modeling work being performed by Norwest will be used to establish hydrogeologic gas migration control parameters, determine appropriate monitoring well spacings, and assess mitigation options as part of CEPL's ongoing expansion toward a commercial scale UCG operation.

Suncor Pond 1 Reclamation

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incorporated a second layer of geogrid and drains. Construction was completed prior to the start of the spring thaw. In May, the area was covered with reclamation soils and planted with native grasses.

In September 2010, Suncor celebrated the successful surface reclamation of Pond 1 (renamed Wapiisiw Lookout), a first for the oil sands industry. Norwest continues to work with Suncor on the project, evaluating the long term stability of the cap and the underlying tailings.

Norwest Denver Unveils Team "Drill 'Em Deep" by Kyle Orr

Norwest's Denver office's summer co-ed softball team, Drill 'Em Deep, competed in eight games over seven weeks, including the championship playoffs. Although never actually winning a game, Drill 'Em Deep was a team to contend with by the end. The team remained open to all in the office, and the roster was ever changing. The team had people who had never thrown or caught a ball, but everyone played well and was willing to learn.

For the last game everyone decided to wear wigs and dress up (see photo)!

From Left: Jim Thomson, Matt Kascak (Co-Captain), Helene Wieting, Landon Beck, Angie Welch, Jake Maybach, Kyle Orr (Co-Captain), Justin Little, Tamarinda Douglas, Konrad Quast
Front Row (from left): Angi Fuller, Magdalena Dohnalova

Not Pictured: Carlos Pereira, Jen Kos, Jeremy Snyder, Michael Kendrick, Paul Kos, Seth Okeson

